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The Impact of Pavement Permeability on Time of Concentration in a Small Urban Watershed with a Semi-Arid Climate

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Abstract
Despite the popularity of the permeable pavements in urban areas in recent years, a few empirical equations have been developed to estimate the time of concentration (Tc) on pervious surfaces, and almost none of them is evaluated over the permeable pavements. In this paper, we aim to investigate the effect of low impact development (LID) on Tc and develop a new equation for estimating overland flow Tc compatible with both permeable and impermeable pavements in small urban watersheds with a semi-arid climate. An experimental model was devised to determine the new equation. Synthetic rainfall (22–40 $mm.h^{-1}$) was applied to a rectangular shaped ($6\ m \times 1\ m$) test watershed with an adjustable longitudinal slope (0.5–8%) and zero lateral slope. Porous asphalt and permeable interlocking concrete paver (PICP) were employed as the permeable pavements. Then, to validate the obtained equation from experimental data, a field study was conducted over a 1-ha watershed during a Low intensity (<4 $mm.h^{-1}$) rain event. The comparison between 13 empirical and semi-empirical equations (including the one developed in this study) for estimating Tc in the test condition indicates that Chen and Wong's equation with −0.03 bias and the Nash-Sutcliffe efficiency (NSE) equal to 0.9 and 0.7 for impervious and pervious surfaces respectively is the most precise equation. On the other hand, for the field study, the newly developed formula outperformed other equations and estimated the Tc with a 3.7% error. Moreover, the results of experiments on the PICP surface showed that replacing 10 to 15% of an urban watershed surface by PICP in a region with the rainfall intensity less than 40 $mm.h^{-1}$ and storm duration less than 1 h causes a considerable reduction (almost 100%) in the surface runoff.

Keywords Time of concentration · Small urban watershed · LID · Porous asphalt · Synthetic rainfall · Permeable pavement

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